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ORIGINAL ARTICLE

Impact of a novel home-based exercise intervention on health indicators in inactive premenopausal women: a 12-week randomised controlled trial

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Abstract

Purpose This study tested the hypothesis that a novel, audio-visual-directed, home-based exercise training intervention would be effective at improving cardiometabolic health and mental well-being in inactive premenopausal women.

Methods Twenty-four inactive premenopausal women (39 ± 10 years) were randomly assigned to an audio-visual-directed exercise training group (DVD; $n = 12$) or control group (CON; $n = 12$). During the 12-week intervention period, the DVD group performed thrice-weekly training sessions of 15 min. Training sessions comprised varying-intensity movements involving multiplanar whole-body accelerations and decelerations (average heart rate (HR) = 76 ± 3% HR_{max}). CON continued their habitual lifestyle with no physical exercise. A series of health markers were assessed prior to and following the intervention.

Results Following the DVD intervention, HDL cholesterol (pre: 1.83 ± 0.45, post: 1.94 ± 0.46 mmol/L) and mental well-being, assessed via the Warwick Edinburgh Mental Well-Being Scale, improved ($P < 0.05$). Conversely, [LDL cholesterol], [triglycerides], fasting [glucose], body composition and resting blood pressure and HR were unchanged following the DVD intervention ($P > 0.05$). There were no pre-post intervention changes in any of the outcome variables in the CON group ($P > 0.05$).

Conclusion The present study suggests that a novel, audio-visual-directed exercise training intervention, consisting of varied-intensity movements interspersed with spinal and lower limb mobility and balance tasks, can improve [HDL cholesterol] and mental well-being in premenopausal women. Therefore, home-based, audio-visual-directed exercise training (45 min/week) appears to be a useful tool to initiate physical activity and improve aspects of health in previously inactive premenopausal women.

Keywords Fitness DVD · High-intensity interval training · Health profile · Women's health · Home-based exercise

Abbreviations

ANOVA	Analysis of variance
BMI	Body mass index
BP	Blood pressure
bpm	Beats per minute
cm	Centimetre
CHD	Coronary heart disease
CON	Control group
CV	Coefficient of variation

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DVD	Audio-visual-directed exercise training group
HDL-C	High-density lipoprotein cholesterol
HR	Heart rate
HR_{max}	Maximum heart rate
kg	Kilogram
MAP	Mean arterial pressure
min	Minute
mL	Millilitres
$ml \cdot kg^{-1} \cdot min^{-1}$	Millilitres per kilogram body mass per minute
mmHg	Millimetres mercury
MRI	Magnetic resonance imaging
LDL-C	Low-density lipoprotein cholesterol
OGTT	Oral glucose tolerance test
RPE	Ratings of perceived exertion
SD	Standard deviation
tAUC	Total area under the curve
TC	Total cholesterol
WEMWBS	Warwick-Edinburgh mental well-being scale
y	Year
YYIE1	Yo-Yo Intermittent Endurance Level 1 test

Introduction

Participation in regular physical activity is associated with decreased morbidity of non-communicable diseases such as cardiovascular disease, obesity, and type II diabetes mellitus (Lee et al. 2012). However, in spite of the well-established health benefits of regular physical activity and despite widespread promotion of physical activity guidelines for health [at least 150 min of moderate-intensity activity or 75 min of vigorous-intensity activity per week (Department of Health and Social Care 2019)], it has been reported that 42% of women in England are not meeting physical activity recommendations. This is higher than the 34% of English men who are not meeting these guidelines (Public Health England 2019). Between the ages of 25–54 years, only 61–66% of women in England are meeting physical activity recommendations whereas 70–76% of their male counterparts are achieving the same recommendations (Townsend et al. 2015). Importantly, physical inactivity is associated with increased use of healthcare services and is estimated to cost the NHS over £900 million annually (Public Health England 2019). These observations underscore the requirement to develop interventions aimed at increasing physical activity participation in inactive women.

One of the most commonly cited barriers preventing women from meeting physical activity recommendations is a lack of time (Welch et al. 2009) due to work and child-care commitments and travel and financial restrictions (Napolitano et al. 2011). In addition, women have been reported to prefer training on their own with instruction (King et al. 2000) or with a family member or friend (Im et al. 2008). Consequently, several home-based exercise interventions have been developed in an attempt to provide a convenient, cost-effective method to increase physical activity adherence in women. Traditionally, home-based exercise interventions delivered through exercise booklets and information sheets have been successful in improving the health profile of premenopausal women (Mediano et al. 2010). However, it has been reported that individuals tend to selectively scan printed exercise information leading to incorrect movement execution compared to other forms of media (Eveland and Dunwoody 2002). This limitation might have a negative impact on the potential health benefits achievable through such interventions.

The use of audio-visual-directed exercise has emerged as a popular choice of physical activity for pre and postmenopausal women (Daley et al. 2011). The complementary use of audio and video may increase motivation and correct exercise execution, through clear visual guidance on exercise movements and session structure, combined with music, subtitles and verbal instruction (Khalil et al. 2012). However, while many audio–visual-directed exercise programmes are commercially available, the exercise regimens tend to be generalised for a wide audience, which might limit their potential to promote participant compliance and health benefits in premenopausal women.

The pre-choreographed, custom-designed exercise programme used within this study incorporated jumps, rebounds, turns and controlled sequences, and balance and coordination challenges similar to activity profiles found in intermittent team sports (Pedersen et al. 2009). These movement patterns were selected based on evidence that female athletes (Nikander et al. 2005) and premenopausal women (Helge et al. 2010) exposed to intermittent exercise of varying intensity and with high strain rates, demonstrate improvements in bone mineral density and in other health profile indices, such as lipid profile, increased lean mass and well-being (Krustrup et al. 2018; Ottesen et al. 2010). This exercise programme has reported high compliance and acceptability in a 6-month feasibility study in pre and perimenopausal women (Scott et al. 2013).

Therefore, the purpose of this study was to investigate adherence to, and the potential health benefits of, a novel, audio–visual-directed exercise training intervention for premenopausal women. It was hypothesised that an audio–visual-directed exercise training intervention completed in the participant's own home would be associated with a high participation rate and improvements in mental well-being and non-communicable disease risk factors in inactive premenopausal women.

Materials and methods

Participants

Participants were recruited through advertisements in local community venues and the University of Exeter news bulletin. No financial or other inducements were offered to participants apart from them being allowed to keep a copy of the exercise programme DVD following completion of the intervention. Potential participants were given the opportunity to contact the research team by phone or in person to confirm that they were premenopausal (the reproductive period of the female reproductive life course) (Harlow et al. 2012), non-smokers, not pregnant or on medication, and without diagnosed metabolic or cardiovascular diseases. It was also confirmed that none of the participants had been taking part in regular physical activity for at least 2 years, as verified via the completion of the International Physical Activity Questionnaire. Although diet was only monitored in the first and last week of the intervention period, participants were instructed not to change their normal dietary practices for the duration of the study and, apart from the intervention, were requested to maintain their normal lifestyle. All participants gave their written informed consent once being informed verbally and in writing of the experimental procedures and potential benefits, risks and discomforts associated with the study. The study was approved by the Sport and Health Sciences Research Ethics Committee at the University of Exeter, Exeter, UK and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. CONSORT guidelines (Schulz et al. 2010) for the reporting of randomised control trials were adhered to throughout.

Design

The study was designed as a two-arm randomised controlled trial. Baseline and follow-up assessments were conducted within the Sport and Health Science laboratories at the University of Exeter while the exercise training intervention took place within the participants own home. Intervention and data collection were conducted throughout 2016 and analysed in 2017. Before the start of the study, an independent researcher prepared sequentially numbered, opaque, sealed envelopes containing the treatment allocation. The random sequence was generated using a computerised random number generator. Directly after baseline assessment, the participants were randomised by a second independent researcher to an audio–visual-directed/streaming exercise training group (DVD) or control group (CON) using the sealed, opaque envelopes. Those participants in the DVD group completed a 12-week training programme, as described below, while CON continued their normal daily lives. After allocation, it was not possible to blind the researchers and participants to the group allocation due to the nature of the training intervention. Before and after the 12-week intervention period, a series of health markers were assessed (see below). The Consolidated Standards of Reporting Trials (CONSORT) flow chart outlining participant flow from first contact to study completion is provided in Fig. 1.

Audio–visual-directed exercise training intervention

Within a 3 × 3 m grid, participants completed 15-min exercise bouts consisting of low-, moderate-, and high-intensity physical activity patterns 3 times weekly. This involved multiplanar whole-body accelerations and decelerations (30 and 60 s intervals followed by 5 s transitions). Each 60 s interval required the action to be completed at low-intensity for 30 s, moderate-intensity for 20 s and high-intensity for 10 s and each interval was interspersed with intervals of active rest (Table 1). This pre-choreographed movement training incorporated slow-speed, moderate-speed, high-speed and backwards running; walking sideways and backwards; and side-cutting, 90° and 180° turns, jumps and stops interspersed with spinal and lower limb mobility, and balance and coordination challenges. A member of the research team made weekly contact with each participant to provide encouragement, receive feedback and answer any queries the participant may have had. Prior to the intervention (prior to the second visit to the laboratory; see below), participants were provided with a DVD and sent a link to a YouTube video which consisted of each section being verbally explained and visually demonstrated at a slow speed and then at actual speed. In addition, all participants were familiarised with the movement sequences in person and instructed on how to set up the exercise space in their own homes (see visit 2 below). In the 6th week of training, participants were asked to revisit the laboratory where they were familiarised with, and provided with the DVD and YouTube link for, a second varied-intensity interval-exercise routine. This second exercise regime incorporated more challenging movements and also allowed for variation in exercise due to the long duration of the exercise intervention (Table 2).

Measurement and test procedures

On the first visit to the laboratory, blood samples were obtained and blood pressure (BP), body anthropometry and composition, oral glucose tolerance and mental well-being were assessed (Fig. 2a). Participants were required to refrain

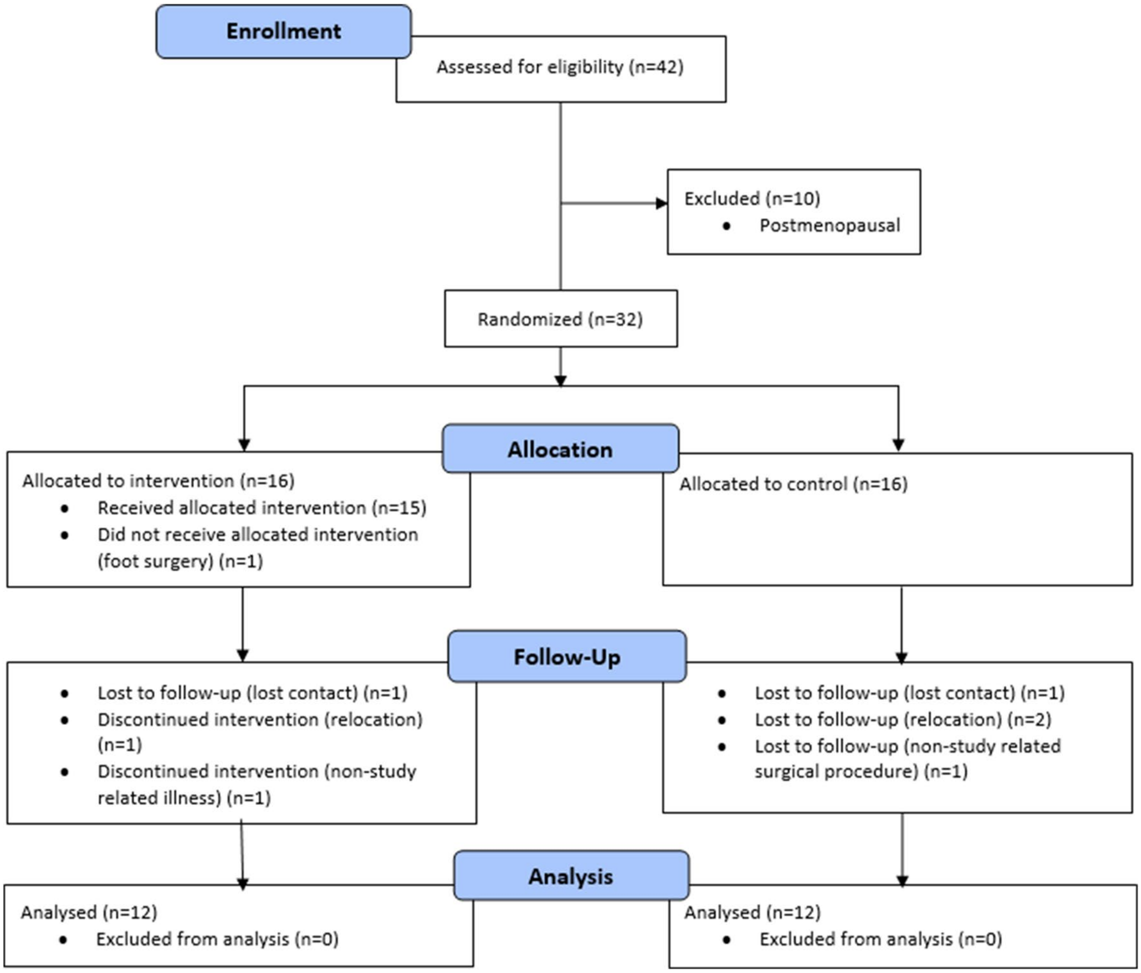

Fig. 1 Consort flow diagram indicating sample sizes at each stage and in each arm of the study

Table 1 Home-based audio-visual-directed exercise training description level 1

Section title	Description
1. 60 s. walk, jog, run	30 s. walk fast—20 s. jog—10 s. run
2. 60 s. Ankle, hip mobility	30 s. ankle plantar-dorsiflexion; 30 s. rear lunge in plantarflexion
3. 60 s. walk, jog, run	60 s. repetition of Sect. 1 at faster speed all actions
4. 60 s. spinal mobility	60 s. spinal side bending, side bending with flexion and extension
5. 60 s. skater	30 s. side step jump turn—20 s. increase speed—10 s. lateral hop
6. 60 s. side mobility	30 s. lateral lunge spinal side bend—30 s. single leg balance task
7. 60 s. diagonal skip and turn	20 s. diagonal step with 180° turn—10 s. faster 180° jump turn—L and R side
8. 60 s. brushes	30 s. single leg balance task- 30 s. repeat balance task with increased hip range of movement
9. 60 s. ¼ turn with fast feet	20 s. step and ¼ turn—10 s. fast footwork side ladder with jump; repeat 20 s. ¼ turn section faster—10 s. repeat side ladder footwork faster
10. 60 s. quadruped mobility	60 s. quadruped kneeling spinal mobility, with modified press up
11. 60 s. folk step	30 s. skip forwards and back—20 s. bound forwards and back—10 s. bilateral jump forward fast jog back
12. 30 s. arrow balance	15 s. rear lunge in narrow base of support arms above head- repeat L and R side
13. 60 s. side cut	30 s. side shuffle—20 s. side cut fast—10 s. lateral bound L to R foot
14. 30 s. hip mobility	15 s. rear lunge with spinal side bend and lateral hip shift—L and R side
15. 60 s. walk, jog, run	60 s. repetition of Sect. 1 at faster speed all actions
16. 30 s. spine mobility	30 s. spinal flexion and extension; ankle plantarflexion

Table 2 Home-based audio-visual-directed exercise training description level 2

Section title	Description
1. 60 s. fast walk, jog, run	30 s. walk fast—20 s. jog—10 s. run
2. 60 s. ankle, hip mobility	30 s. ankle plantar-dorsiflexion; 30 s. rear lunge in plantarflexion
3. 60 s. walk, jog, run	60 s. repetition of Sect. 1 at increased speed all actions
4. 60 s. spinal mobility	60 s. spinal side bending, side bending with flexion and extension
5. 60 s. skater	30 s. side step jump turn—20 s. increase speed—10 s. lateral hop
6. 60 s. side mobility	30 s. lateral lunge spinal side bend—30 s. single leg balance task
7. 60 s. diagonal skip and turn	20 s. diagonal step with 180° turn—10 s. faster 180° jump turn—L and R side
8. 60 s. brushes	30 s. single leg balance task- 30 s. repeat balance task with increased hip range of movement
9. 60 s. ¼ turn with fast feet	20 s. step and ¼ turn—10 s. fast footwork side ladder with jump; repeat 20 s. ¼ turn section faster—10 s. repeat side ladder footwork faster
10. 60 s. elevated quadruped	60 s. elevated quadruped- modified push up- push up and spinal rotation
11. 60 s. folk step with jumps	30 s. fast skip forwards and back—20 s. bound forwards and back—10 s. continuous bilateral jumping forward and backwards
12. 30 s. arrow balance	15 s. rear lunge in narrow base of support arms above head-repeat L and R side
13. 60 s. dynamic side cut	30 s. dynamic lateral shuffle—20 s. dynamic lateral cutting—10 s. dynamic lateral bound L to R foot
14. 40 s. giant steps	40 s. alternating single leg balance with plantar flexion and increased hip range of movement gesture leg-L–R; L–R
15. 60 s. jog, run, sprint	60 s. repetition of Sect. 1 at increased speed all actions
16. 60 s. spine mobility	60 s. spinal flexion, extension, rotation; ankle plantarflexion whole body elevation

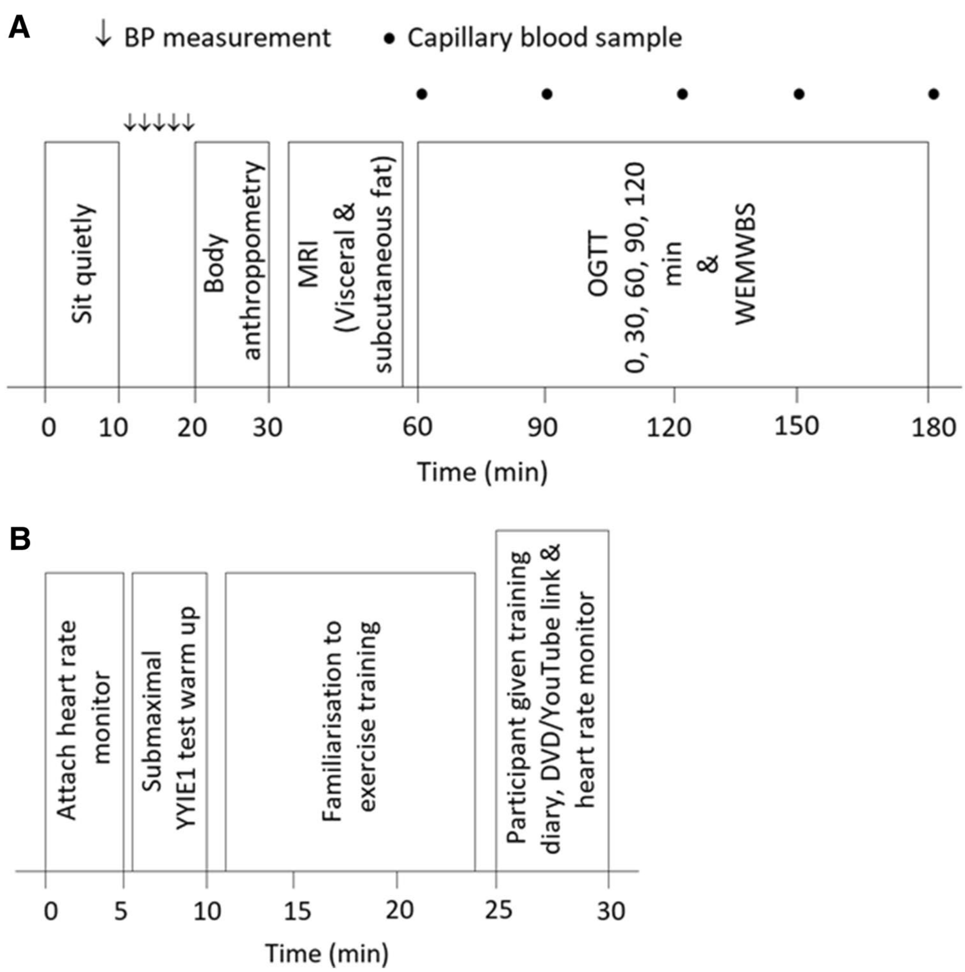

Fig. 2 Schematic representation of the experimental protocol. **a** Visit 1. **b** Visit 2. *BP* blood pressure, *OGTT* oral glucose tolerance test, *MRI* magnetic resonance imaging, *WEMWBS* Warwick-Edinburgh Mental Well-being Scale, *YYIE1* Yo-Yo intermittent endurance level 1 test

from alcohol and exercise for 48 h preceding the first test day and to report to the laboratory after an overnight fast at 08:00.

Blood sampling and BP assessment

After arriving at the laboratory, resting HR and BP were measured following the participant sitting quietly for ten minutes. BP was measured five times using a semi—automated device (Dinamap Pro 100V2, GE Medical Systems Information Technologies 2002, Tampa, Florida, USA) with the mean of the final three measurements used to determine resting systolic and diastolic BP. Mean arterial pressure (MAP) was subsequently calculated as (1/3 × systolic pressure) + (2/3 × diastolic pressure). Thereafter, 4 mL of whole blood was drawn from an antecubital vein into serum separator tubes (Vacutainer, Becton–Dickinson, NJ, USA) and left to clot for 30 min at room temperature. Samples were then centrifuged at 1300 RCF for 10 min and serum supernatants were removed and stored at – 80 °C for later analysis. Samples were analysed using an automated analyser (Roche Modular P-module, Roche Diagnostics, Indianapolis, IN) for [high-density lipoprotein cholesterol] (HDL-C) (CV 2.1%), [total cholesterol] (TC) (CV 2.3%) and [triglycerides] (CV 2.4%). [Low-density lipoprotein cholesterol] (LDL-C) was derived using the Friedewald formula (Friedewald et al. 1972).

Body anthropometry

Height (Seca stadiometer SEC-225; Seca, Hamburg, Germany), body mass (Seca digital column scale SEC-170, Seca, Hamburg, Germany), body mass index (BMI, in kg/m^2) and waist-to-hip ratio were obtained prior to testing.

Body composition

Quantification of visceral and abdominal adipose fat was undertaken via magnetic resonance imaging (MRI) scans (1.5 T Intera scanner, Philips, The Netherlands). A series of 8 mm slices (2 mm × 2 mm in-plane resolution), with 2 mm gap, were acquired centred around L3 (Demerath et al. 2007). A fast gradient echo sequence was utilised with water suppression via a frequency selective binomial excitation to obtain fat selective images. Fat quantification for each slice was undertaken using software present within the scanner package based on intensity windowing such that only voxels containing fat were included. Measurements were carried out to determine a cross sectional area of separate subcutaneous and visceral fat components within a single slice at L3 and volumes over five slices centred around L3.

Oral glucose tolerance test (OGTT)

Following the assessment of body composition, participants provided a capillary blood sample for fasting plasma [glucose] and [haemoglobin]. Participants then consumed 75 g of glucose in 300 mL of water with capillary blood samples collected at 30, 60, 90 and 120 min for assessment of plasma [glucose] using a YSI 2300 glucose analyser (Yellow Springs Instruments, Kent, UK). Throughout the 2 h OGTT, participants remained in the laboratory completing only sedentary activities. Changes in plasma [glucose] during the OGTT were quantified using total area under the curve (tAUC) analyses employing the trapezium rule (GraphPad Prism, San Diego, CA, USA).

WEMWBS

During the OGTT, subjective mental well-being was measured using the 14-item Warwick-Edinburgh Mental Well-being Scale (WEMWBS) (Tennant et al. 2007). WEMWBS was scored by summing responses (i.e. 1 = none of the time to 5 = all of the time) to each of the 14 items. Permission to use WEMWBS was granted by the University of Warwick. Higher scores were related to increased well-being.

During visit 2, participants were asked to wear a HR monitor (Polar RS400, Polar Electro Oy, Kempele, Finland) and were familiarised with the training intervention so they could exercise safely and correctly at home (Fig. 2b). Prior to familiarisation, participants completed a submaximal version of the Yo-Yo Intermittent Endurance Level 1 test (YYIE1). This required participants to complete the first six 20-m shuttle runs of the YYIE1. After each 40-m run, the participants had a 5 s active recovery period during which they walked 2 × 2.5 m. The YYIE1 was used as a warm up but also to determine whether sub-maximal exercising HR was impacted by the 12-week intervention. On completion of this session, participants were provided with a training diary, exercise DVD/YouTube link and a recordable HR monitor (Polar RS400, Polar Electro Oy, Kempele, Finland) which they were asked to wear during all training sessions. A typical HR trace of a single training session from week 0–6 (A) and 7–12 (B) can be seen in Fig. 3. Participants were also asked to record ratings of perceived exertion (RPE, 10-point scale) after every session.

Statistics

Data were analysed using the Statistical Package for the Social Sciences (SPSS v23. SPSS Inc., Chicago, IL, USA). Mean differences between groups at baseline were assessed using independent *t* tests. A two-factor mixed-model ANOVA was used to test for group (DVD versus CON) and time (pre-intervention versus post-intervention)

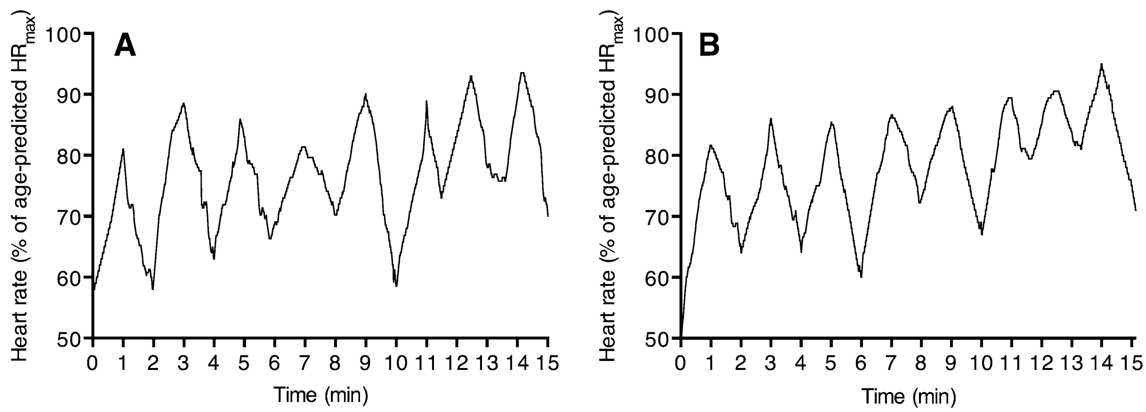

Fig. 3 Exemplar heart rate during a single level 1 (**a**) and level 2 (**b**) training session for a single participant from the home-based audio-visual-directed exercise group. *HR* heart rate

main effects and group × time interaction effects for all variables apart from the 2-h OGTT. Responses to the OGTT data were analysed using a three-factor mixed-model ANOVA, with the factors 'group' (DVD *versus* CON), 'time' (pre-intervention *versus* post-intervention) and 'duration' (0, 30, 60, 90 and 120 min). Effect size was calculated using partial η^2 with 0.01, 0.06 and 0.14 regarded as small, moderate and large effects (Cohen 1988). Where ANOVAs revealed significant differences, post hoc comparisons were undertaken with the α-level adjusted using a Bonferroni correction. The significance level was set at $P < 0.05$. Data are reported as mean ± SD.

Results

Baseline characteristics

Forty-two women were initially assessed for eligibility to the study. However, 10 were excluded as they were postmenopausal. Thirty-two women were randomised to either the audio-visual-directed exercise training group (DVD) or the control group (CON). In total, eight participants withdrew from the study due to relocation, loss of contact, illness or surgery unrelated to the interventions (Fig. 1). The baseline characteristics for the DVD group were: age; 41 ± 8 (mean ± SD) (range 24–52) years, height; 1.70 ± 0.07 m, body mass; 66.1 ± 14.5 kg; $n = 12$] and for the CON group were: age; 38 ± 11 (20–49) years, height; 1.63 ± 0.05 m, body mass; 74.8 ± 19.3 kg; $n = 12$]. No statistical differences were seen among the two groups at baseline other than visceral fat (Table 3).

Training data

The DVD group completed a total of 36 ± 1 training sessions over the 12-week period, corresponding to 2.9 ± 0.4 sessions per week equivalent to 45 min per week. Home-based mean session HR during 0–6 weeks (74 ± 4% HR_{max}) was significantly lower ($P < 0.01$) compared to 7–12 weeks (77 ± 3% HR_{max}). The mean HR during the baseline supervised laboratory-based session was not significantly different to the home-based sessions during week 0–6 (78 ± 8 vs 74 ± 4% HR_{max}, $P > 0.05$), however, mean HR during the 12th week supervised laboratory-based session was significantly higher ($P < 0.01$) than the home-based sessions during weeks 0–6 (83 ± 5 vs 74 ± 4% HR_{max}) and 7–12 (83 ± 5 vs 77 ± 3% HRmax) (Table 4). In addition, the mean HR during the 6th week laboratory-based follow-up session was significantly higher than the home-based sessions during weeks 7–12 (81 ± 4 vs 77 ± 4% HR_{max}, $P < 0.01$). HR_{max} achieved during the supervised laboratory-based sessions at 0, 6 and 12 weeks was 94 ± 6, 97 ± 2 and 95 ± 4% HR_{max}. HR_{max} achieved during the home-based training sessions was not significantly different when comparing 0–6 and 7–12 weeks (92 ± 2 and 93 ± 2% HR_{max}, $P > 0.05$). RPE during the first 6 weeks (Level 1 DVD, RPE: 7 ± 2) was not different ($P > 0.05$) to the following 6 weeks (Level 2 DVD, RPE 7 ± 1). HR during the last 15 s of the submaximal YYIE1 was not significantly different after 6 and 12 weeks of training ($P > 0.05$) compared to baseline (Table 4). No accidents or adverse events related to exercising were reported.

Table 3 Outcome measures pre and post 12-week intervention

	DVD ($n=12$)		CON ($n=12$)		Interaction effect	
	Pre	Post	Pre	Post	P	Partial η^2
Body mass (kg)	66.1 ± 14.5	66.9 ± 15.3	72.9 ± 19.5	73.1 ± 19.5	0.485	0.022
BMI (kg/m^2)	23.7 ± 5.0	24.0 ± 5.1	28.2 ± 6.2	27.4 ± 6.8	0.074	0.138
Waist-to-hip ratio	0.82 ± 0.07	0.82 ± 0.04	0.86 ± 0.09	0.87 ± 0.04	0.646	0.012
Subcutaneous fat			$n=9$	$n=9$		
Single (cm^2)	179.3 ± 121.2	180.1 ± 121.7	324.1 ± 169.9	313.7 ± 163.9	0.263	0.066
Volume (cm^3)	905.2 ± 609.9	901.6 ± 602.7	1649.2 ± 832.2	1572.2 ± 828.6	0.188	0.089
Visceral fat			$n=9$	$n=9$		
Single (cm^2)	53.8 ± 52.8[a]	57.7 ± 57.5[a]	92.9 ± 62.8	99.1 ± 70.1	0.745	0.006
Volume (cm^3)	288.3 ± 297.4[a]	274.3 ± 280.5[a]	461.2 ± 308.0	479.4 ± 329.8	0.353	0.046
Resting systolic BP (mmHg)	113 ± 16	112 ± 17	114 ± 16	117 ± 22	0.453	0.029
Resting diastolic BP (mmHg)	70 ± 10	70 ± 11	70 ± 10	70 ± 11	0.864	0.001
MAP (mmHg)	85 ± 11	84 ± 12	86 ± 10	88 ± 14	0.569	0.016
Resting HR (bpm)	71 ± 12	67 ± 8	72 ± 15	69 ± 11	0.865	0.001
Fasting blood [glucose] (mmol/L)	3.48 ± 1.03	3.93 ± 0.48	3.52 ± 1.06	3.75 ± 0.67	0.659	0.009
tAUC (mmol/L[a] 120 min)	700 ± 110	663 ± 90	613 ± 198	621 ± 99	0.375	0.036
Hb (g/L)	132 ± 13	133 ± 13	134 ± 7	131 ± 8	0.462	0.027
[TC] (mmol/L)	4.67 ± 1.61	5.04 ± 0.68	4.44 ± 0.70	4.71 ± 0.52	0.849	0.002
[HDL-C] (mmol/L)	1.83 ± 0.45	1.94 ± 0.46[a]	1.54 ± 0.43	1.49 ± 0.35	0.064	0.147
[LDL-C] (mmol/L)	3.07 ± 0.76	2.84 ± 0.74	2.70 ± 0.65	3.01 ± 0.57	0.095	0.127
TC/HDL ratio	2.80 ± 0.59	2.57 ± 0.58	2.63 ± 1.07	2.88 ± 1.22	0.108	0.118
HDL/LDL ratio	0.7 ± 0.4	0.8 ± 0.3	0.6 ± 0.3	0.5 ± 0.2	0.131	0.105
[Triglycerides] (mmol/L)	0.73 ± 0.27	0.75 ± 0.30	0.98 ± 0.57	1.02 ± 0.59	0.938	0.000
WEMWBS	55 ± 4	58 ± 6[a]	52 ± 4	51 ± 6	0.056	0.156

Vales are expressed as mean ± SD

P values for interaction (group × time) effect

BMI body mass index, *BP* blood pressure, *MAP* mean arterial pressure, *HR* heart rate, *tAUC* total area under the curve, *Hb* haemoglobin, *TC* total cholesterol, *HDL-C* high density lipoprotein cholesterol, *LDL-C* low density lipoprotein cholesterol, *WEMWBS* Warwick–Edinburgh Mental Well-being Scale

[a]Denotes significant difference between groups ($P < 0.05$). Partial η^2 value for effect sizes

Body anthropometry

There were no interaction or condition effects for body mass, BMI or waist-to-hip ratio ($P > 0.05$, Table 3). A main effect of group was apparent for subcutaneous fat ($P < 0.05$). Post hoc analysis revealed that subcutaneous fat was lower in the DVD group compared to CON before ($P < 0.05$) and after ($P < 0.05$) the intervention period (Table 3).

Resting BP and HR

Resting BP variables and HR were not significantly different following the intervention period in the DVD or CON groups ($P > 0.05$, Table 3).

Fasting blood glucose and OGTT

Fasting blood [glucose] was unchanged in the DVD and CON groups after the 12-week intervention period ($P > 0.05$, Table 3). A main effect of duration was apparent during the OGTT ($P < 0.01$), however, there were no time × group, duration × group, time × duration or time × duration × group interactions with regard to the blood [glucose] during the OGTT ($P > 0.05$; Fig. 4). There were also no differences in the blood glucose tAUC ($P > 0.05$, Table 3).

Serum lipids and haemoglobin

[Haemoglobin], [TC], TC/HDL ratio, [LDL-C], HDL/LDL ratio and [triglycerides] were unchanged following the 12-week intervention period ($P > 0.05$, Table 3). However,

Table 4 Heart rate and ratings of perceived exertion data during audio-visual-directed exercise training intervention

	DVD ($n = 12$)
Mean single session HR (% HR_{max})	
Baseline	78 ± 8
6-week follow up	81 ± 4
12-week follow up	83 ± 5
Mean training HR (% HR_{max})	
0–6 weeks	74 ± 4[a]
7–12 weeks	77 ± 4[b, c]
Submaximal YYIE1 HR (bpm) (final 15 s)	
Baseline	151 ± 12
6-week follow up	149 ± 10
12-week follow up	148 ± 7
Mean training RPE	
0–6 weeks	7 ± 2
7–12 weeks	7 ± 1

Values are expressed as mean ± SD

HR heart rate, *RPE* ratings of perceived exertion, *YYIE1* Intermittent Endurance level 1

[a]Denotes significant difference between mean heart rate during first 6 weeks of home-based training compared to supervised follow up session at 6 weeks

[b]Denotes significant difference between mean heart rate during final 6 weeks of home-based training compared to supervised follow up session at 12 weeks

[c]Denotes significant difference between home-based mean HR during 0–6 and 7–12 weeks

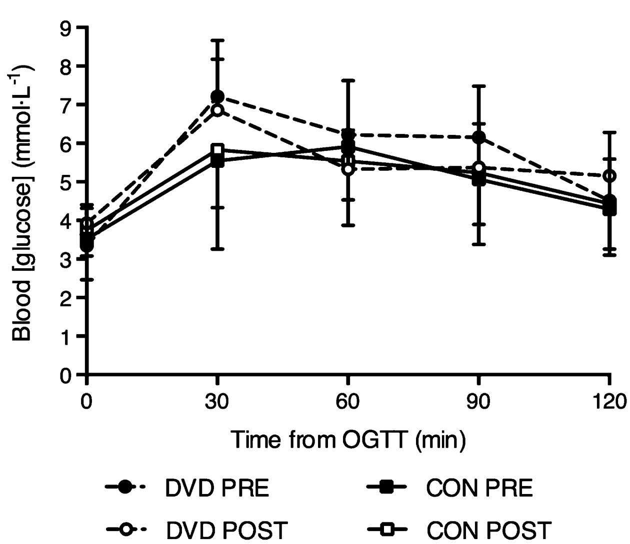

Fig. 4 Blood [glucose] response following the oral glucose tolerance test OGTT displayed over time for the audio-visual-directed exercise (DVD) and control (CON) group before and after the 12-week intervention. Data are mean ± SD

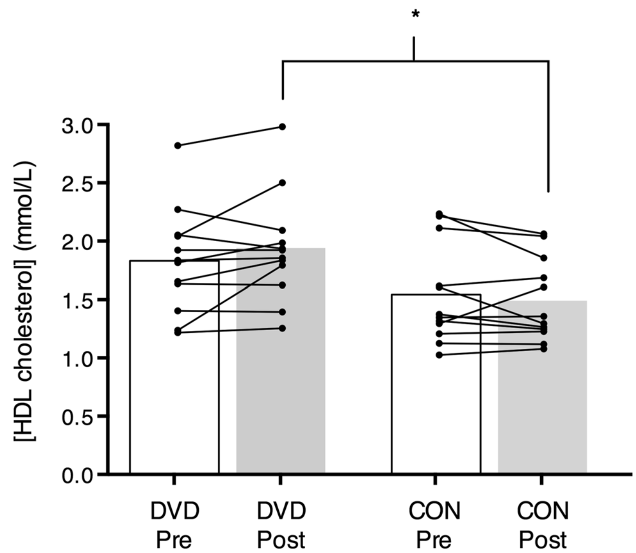

Fig. 5 [High-density lipoprotein (HDL) cholesterol] before and after 12 weeks of home-based audio-visual-directed exercise (DVD) or continuation of an inactive lifestyle (CON). Mean and individual values are presented for pre and post. *Denotes significant difference between groups following intervention period

there was a main effect for group ($P < 0.05$) and a tendency for a time × group interaction for [HDL-C] ($P = 0.06$, Table 3). Post hoc analyses revealed that, following the audio-visual-directed exercise intervention, [HDL-C] was higher ($P < 0.05$, Fig. 5).

WEMWBS

There was a tendency for a time × group interaction ($P = 0.06$) with post hoc analysis revealing that mental well-being was higher in the DVD group compared to the CON group following the intervention period ($P < 0.01$, Table 3).

Discussion

The main findings from the present study were that a home-based, audio-visual-directed exercise training intervention, which involved bouts of multiplanar whole-body accelerations and decelerations, improved [HDL-C] and mental well-being in inactive premenopausal women. However, [LDL-C], [triglycerides], fasting [glucose], body composition and resting BP and HR were unchanged following the audio-visual-directed training intervention. High levels of compliance with this small-volume, home-based, audio-visual-directed exercise programme indicate potential for initiating behaviour change in physical activity levels and time-efficiently improving aspects of health in previously inactive premenopausal women.

In the present study, 12 weeks of home-based, audio-visual-directed exercise, comprising 3 weekly sessions of 15 min, increased [HDL-C] by 0.11 mmol/L with no change in the CON group. This is in line with reports suggesting that [HDL-C] is the constituent of the lipid profile which is most likely to improve following physical activity (Mann et al. 2014). This is important as increased [HDL-C] affords protection from atherosclerosis and coronary heart disease (CHD) (Barter 2005). Moreover, the magnitude of the [HDL-C] improvement in the DVD group (0.11 mmol/L) is likely to be of clinical significance as every 0.026 mmol/L increase in [HDL-C] corresponds to a 2–3% reduction in CHD prevalence (Gordon et al. 1989). Our finding of improved [HDL-C] following the home-based exercise training intervention is consistent with a study reporting improvements in the blood lipid profile of previously inactive women after completing a small-sided football training intervention (Krustrup et al. 2010). A common feature of our training intervention and the football training (Krustrup et al. 2010) is the incorporation of numerous high-intensity accelerations and decelerations. These exercise patterns might provide a potent stimulus for upregulating anti-inflammatory and anti-oxidant pathways leading to a reduction in HDL-C oxidation to [LDL-C] (Dekleva et al. 2017; Kannan et al. 2014). Although not measured in the present study, mechanisms for increased [HDL-C] may be related to increase in lipoprotein lipase activity (LPL) and lecithin-cholesterol acyltransferase which have been shown to increase following exercise training (Mann et al. 2014; Riedl et al. 2010). Therefore, the present results suggest that, for those leading an inactive lifestyle, even exercising for ~ 45 min per week, which is lower than the recommended guidelines (Department of Health and Social Care 2019), has the potential to improve serum [HDL-C]. However, while participants completed food diaries in the first and final week of the intervention and these were consistent, diet was not directly controlled for the entire intervention, therefore, it is possible that a portion of the improvement in [HDL-C] might be linked to changes in diet.

Mental well-being, as assessed by the WEMWBS, was improved following the 12-week home-based exercise training intervention, with no change apparent for the CON group. This is similar to the findings of Cugusi et al. (2016) and Donath et al. (2014) following group dance-/or intermittent-based exercise interventions for women. This is of interest as improved mental well-being through physical activity has been linked to an improved quality of life (Gillison et al. 2009) with individuals less likely to suffer clinical depression (Belvederi Murri et al. 2018), anxiety (Martínez-Domínguez et al. 2018) and psychological distress (Perales et al. 2014). Notwithstanding the positive effects of exercising in a group setting in certain population groups, persuading inactive individuals to participate in group activities may present some challenges. Indeed, when 2,912 women aged ≥ 40 years were questioned on their preferred exercise setting, 62% of respondents rated exercising alone with instruction as more appealing than undertaking exercise in an instructor-led group (King et al. 2000). The present study suggests that limited face-to-face consultations in combination with telephone communication may be a cost-effective approach to maintain participation in exercise and improve mental well-being. It should be acknowledged, however, that the request for participants to wear a HR monitor during all training sessions may have also influenced training adherence as participants were aware that this would indicate to the researchers whether a given training session had been completed or not.

In the present study, audio-visual-directed exercise training did not impact body mass, BMI and waist-to-hip ratio. It should be noted that subcutaneous fat was significantly lower in the DVD group compared to CON prior to the intervention and this difference remained following the 12-week intervention period. However, no within-group pre-to-post intervention differences in subcutaneous and visceral fat occurred. Modest reductions in waist and hip circumferences, as well as reductions in total fat mass, have been reported following 12–16 weeks of dance-related exercise conducted 2–3 times per week in overweight women (39–51 years) (Barene et al. 2013; Cugusi et al. 2016; Krishnan et al. 2015). The lack of change in body mass in the present study compared to previous studies reporting improvements in body mass following home-based exercise interventions (Barene et al. 2013; Cugusi et al. 2016; Krishnan et al. 2015) may be due to a larger body mass (71–94 vs 66 kg) prior to the intervention, longer session durations (60 vs 15 min) or longer training programmes compared to the current study. However, it is also possible that completing the exercise intervention at home influenced the level of effort and energy expenditure in a given session compared to exercise completed under supervision and/or in a class setting.

There were no changes in resting HR, systolic and diastolic BP, and MAP following the DVD and CON interventions in the current study. This lack of an effect of the audio-visual-directed exercise training intervention on these cardiovascular health markers might be linked to the healthy values observed at baseline or that the total training volume may not have been sufficient to elicit further gains. Indeed, baseline values for systolic and diastolic BP were 113/70 mmHg for the DVD training group and it has been reported that resting BP and HR are not impacted following 12 weeks of home-based dance/intermittent exercise interventions when BP values are healthy at baseline (Barene et al. 2013; Connolly et al. 2014). Similarly, no changes in fasting blood [glucose] and blood [glucose] responses during the OGTT were evident following the 12-week intervention for both the DVD and CON groups.

Again, this might be a function of fasting glucose values within the normal healthy range. Similarly, no change in fasting [glucose] was reported by Krishnan et al. (2015) following dance-based exercise with baseline values of 6.5 mmol/L. However, while the home-based, audio-visual-directed exercise training intervention administered in the current study did not improve body composition, cardiovascular health markers and blood glucose regulation in the relatively healthy premenopausal women who participated in the current study, further research is required to assess whether this method of exercise training has potential therapeutic value in individuals with obesity, hypertension, insulin resistance and other non-communicable diseases. It is also unclear whether greater benefits might have been achieved if exercise intensity during independent training at home had matched intensities for supervised sessions. Moreover, further research is required to establish the mechanisms for the improvements in blood [HDL-C] and mental well-being observed for this novel, home-based exercise intervention, and how monitoring HR during all training sessions, and frequent correspondence with participants, may have impacted on adherence to the training intervention and the amount of effort participants were willing to expend in each session.

In conclusion, the present study demonstrated that a novel, home-based, audio–visual-directed exercise training programme can improve [HDL-C] and mental well-being in previously inactive premenopausal women. Furthermore, the high adherence to the 12-week intervention suggests that this type of training is an acceptable exercise modality for premenopausal women. However, while this led to meaningful improvements in [HDL-C] and mental well-being, it was not effective at improving resting BP and HR, blood glucose regulation or body composition in this relatively healthy population. Therefore, our results suggest that an audio-visual-directed, home-based exercise training intervention, can improve some aspects of health in previously inactive premenopausal women.

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Author contributions LC, SS, JF, AJ, KK, PK, SB and JB conceived the presented idea and designed the study. SS was involved in producing the exercise training protocol and training the participants for unsupervised exercise training at home. LC, SS and CM were involved in participant recruitment. LC, SS, CM and JF performed the data collection. LC, SS, CM and JF performed the analysis. All authors discussed the results and contributed to the final manuscript.

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Compliance with ethical standards

Conflict of interest The authors have no conflict of interests to declare.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (The Sport and Health Sciences Research Ethics Committee at the University of Exeter, Exeter, UK. Ref: 141015/A/01) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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